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[title page]

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THE METAL INDUSTRY OF THE AZTECS

By GEORGE BRINTON PHILLIPS

I

121 325 THE collections of many thousand copper objects, tools, weapons, and ornaments from ancient Indian burial mounds and village sites in the Unites States of North America is strong evidence in favor of a pre-Columbian copper industry with which the aborigines were familiar before they reached the Iron Age. Did this knowledge and use of copper extend into Mexico and adjacent country of Central America?

325 Prescott in his *Conquest of Mexico* gives a picturesque account of the splendors of the court of the Montezumas with its silver and gold ornaments and utensils, but the knowledge of metals does not seem to have extended to the general use of copper or bronze for tools and weapons. The Aztec in the production of ornaments in the precious metal showed great skill and artistic workmanship and specimens sent over to Spain were greatly admired by the Spanish goldsmiths. Owing to scarcity of copper [412] in their immediate vicinity, the ancient Mexicans confined its use to adze blades, chisels and some copper objects, possibly ceremonial implements. The tools were hardened by hammering and used in wood carving. The stone cutting it is believed was still done with flint tools.

317 325 Copper was obtained from the mines of Zocotallan where it occurred in masses on the surface and also from the galleries opened in the rock. Ancient workings have been discovered at Cerro del Aguilar in Guerrero, and the Zapotec country was well known for its copper mines. Deposits of tin were also found in Guerrero at the mines of Tasco, and it is said that Cortez obtained enough tin from that source with the copper to cast several large cannon, which he used in his fortress at the siege of Mexico. This use of tin in making a suitable alloy it is believed was due to the familiarity the Spaniards had of bronze, rather than to Aztec knowledge of the art.

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The Aztec people had, however, some knowledge of metallurgy, for they melted the copper and cast it in moulds, an art which the aborigines in the United States never seem to have acquired. Cortez tells us that in the markets of the City of Mexico

> "hatchets were sold made of copper alloyed with tin and that this alloy was used with a silicious powder with which they cut the hardest stones."

The Spanish historians speak of Cholula, a very ancient City of Mexico, founded before the arrival of the Aztec, which excelled in metal working, and that the Tarascans living west of the valley of Mexico were familiar with copper found in the mountains in that district, which they worked into defensive armor, body plates of wood covered with sheet copper. They also state that the Zapotec made ornaments of copper obtained from the mines in Oaxaca.

Copper implements, however, were not common near the City of Mexico but were plentiful in Oaxaca, Michoacan, and the Jalisco region. The T-shaped implements were found at Mitla, Central America, being abundant in the Zapotec country. The objects, some made of very thin sheet copper, others heavier, possibly cast, are of uncertain use; those too thin to be used as tools for wood or stone, are thought to be instruments used in their feather work or pottery, others regard them as a money currency or exacted as tribute paid to the City of Mexico by the neighboring cities, this latter being the general opinion.

The number as well as the variety of copper objects from Mexico found in our Museum collections, is rather limited, consisting of a few copper ax heads, chisels, large and small, little bells, finger rings, beads and pins. The peculiar T-shaped objects are the most abundant, differing somewhat in shape and size. An analysis of one of them in the Peabody Museum at Cambridge, proved it to be simply copper. It was doubtful if the ancient Aztec had a knowledge of bronze or knew how to obtain it until shown by the Spanish invaders, and such analyses of Mexican metal objects, giving a percent of tin to indicate a true bronze, may have been implements made after the instruction by the Spaniards. Some copper tools from Mexico when analyzed showed a small amount of tin believed to have been an impurity in the

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325 copper ore. A chisel reported in the "Anales del Museo de Mexico" quoted by Sir John Evans, in his *Ancient Mexican Implements* when analyzed gave copper 97.87%, tin 2.13%, not sufficient to make a true bronze. Copper axes from Oaxaca, some heavy metal, apparently cast in a mould, others thin, shaped from sheet copper, have been analyzed and yielded only copper, showing they were *not* bronze.

A recent analysis was made for the writer of a portion of a metal chisel of Aztec origin from the village of Acatlan, in the State of Guerrero, Mexico. It was doubtless authentic being sent by Dr. Manuel Gamio, Direccion Anthropologia, Mexico, for analysis, which was made by Dr. D. L. Wallace of the University of Pennsylvania, Analytical Department. The piece of metal apparently broken from the middle of the chisel weighed 88 gms. It was 30 mm. long, 20 mm. wide and 15 mm. thick. It had a brown patina of oxidation, gave clean metal borings (used in the analysis) of dark red bronze color, and had the appearance of having been cast in an open mould. The specific gravity of the metal was 8.00 compared with Lake Superior native copper 7.50. The analyses yielded results as follows:

Copper	91.40%
Tin	3.07%
Lead	0.82%
Iron	0.53%
Cobalt	0.09%
Sulphur	0.82%
	96.73%
Thallium	?

Other metals often associated with Copper were tested for and not found, but tests indicated Thallium. This element Thallium occurs in some copper ores in Mexico as the mineral Crookesite, a copper Thallium selenite sulphide; and it is believed the portion unaccounted for in the analysis was due to the Thallium. [317]

325 301 The little copper bells in the Museum collections seem to have been found in Mexican sites as well as in Central America, and are quite abundant in some localities. Some of these bells were about one half to three-quarters of an inch long, others of more than two inches and of different shape.

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S. G. Morley in his description of Copan says:

"The discovery of copper bells of Mexican origin at a number of archeaological sites in Arizona and New Mexico clearly point to trade relations between the Pueblo Indians and the tribes of Central America in pre-Columbian times; these bells very closely resemble the copper bells found in the sacred Cenates of Chichen Itza, Yucatan, which can hardly have been carried there before 1200 A. D.

Analysis has proved these metal bells to be copper with some little impurities; and it is believed they were cast by what is known as the *cire perdue* process. This method consists in using a wax model, or a core of clay covered with a wax pattern, the mould being heated, the wax melted and ran out, leaving the shape of the object to be cast, which was then filled with the melted metal. This is interesting because this process was well known to the makers of bronze ornaments in Europe, and it is a question if these little bells found in the Aztec or Maya burials were made by the *cire perdue* process; was it a discovery by the American race independent of foreign knowledge?

This might suggest a greater antiquity for this art of casting than that in Europe and would show a considerable amount of experience in metallurgy for the aborigines, and it is surprising that more elaborate objects were not made by them. Judging from the character and variety of cast objects of bronze from South America, the ancient Peruvians were familiar with the *cire perdue* method. Did the Inca discover it? They were certainly the earliest users of the alloy bronze in America with the exception of the unknown builders of Tiahuanaco, among whose ruins have been found bronze tools. With regard to the knowledge the Aztecs had of bronze, it is difficult to establish their claim until more analyses are made of specimens of undoubted Mexican origin, indicating an alloy with a composition of about 90% copper and 10% tin. The following analyses by P. Rivet, taken from his contribution in the *Journal de la Société des Américanistes de Paris* show to what extent tin was used by the Aztecs in their metal objects.

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Objects from Mexico

Locality	*Object*	*Copper*	*Tin*
Valley of Mexico	Chisel	97.87%	2.13%
Atotonilco	Hatchet	98.05%	1.91%
Tlaxiaco	"	99.61%	0.17%
Tlacolula	"	Copper	No tin
Oaxaca	"	"	"
Mexican	Bell	"	"

Other metal objects of Mexican origin yielded thus:

Currency hatchets	25 samples	All copper	No tin
Knife hatchets	5 "	"	"
Flat hatchets	7 "	"	"
Chisels	8 "	"	"
Hatchets	13 "	3 samples with no tin	
Lance points	7 "	1 " " " "	
Bells	26 "	Copper " "	

[411]

Some 28 objects, when analyzed, showed the presence of tin was intentional. Punches, lance points and needles were bronze, while money hatchets, and thin hatchet blades contained no tin. Of 108 samples of metals analyzed, only 38 contained tin. Lance points and chisel hatchets had from 2.13% to 3.4% tin. Two specimens of hatchets contained 9.3% of tin. But it is a question, were they of pre-Columbian origin or made *after* the arrival of the Spaniards?

From the analyses of the Mexican metal objects it is evident that tin was not generally employed for obtaining a hard alloy, which required about 10%. The small amount of tin usually found would rather indicate an accidental impurity in the copper than an intentional ingredient in the alloy.

That the ancient Mexicans or Aztec people were familiar with the metallurgy of gold, silver and copper, the process of hammering, fusing and casting, there is no doubt, and that they understood soldering and even the plating of gold and silver on copper is suggested by the specimens in the museum collections.

The Bronze Age as determined by analyses of the specimens described, is still a matter of doubt for the Aztec, and must

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remain an open question until it can be decided by finding more specimens of recognized bronze composition, and of undoubted Mexican manufacture of pre-Columbian date.

II

MA 325 MA [439]

The Maya were in the Stone Age in pre-Columbian times, although in the latter part of the Second Empire, they seem to have developed a knowledge of working the precious metals and copper; possibly this was due to the facility of obtaining copper and other metals from the neighboring provinces of Mexico with whom they traded. Copper objects said to be from Central America are not numerous in our museums, and although the old Spanish writers speak of "Bronze" it is doubtful if they knew the chemical composition of that metal and how it differed from Copper. Some metal specimens from Central America have been analysed. Small bells, needles and figurines from Chiriqui proved to be copper with no tin. Some bells contained 80% of Copper and 20% of gold. Of course none of these were Bronze. Some little bells from Bolivia and Argentina analysed Copper 99.35% and Tin 0.65%. The tin doubtless was an impurity in the Copper.

Mi 325 171

Mi MA 325 171

Another metal object said to be found in Central America is a T-shaped implement like those common in Mexico. A specimen said to be of Maya origin from the Peabody Museum, Cambridge, when analysed, proved to be simply *Copper*. A small copper bell from Yucatan upon analysis gave;

Copper	97.00%
Tin	.34%
Lead	1.00
Iron	.07%
	98.41%

A small bell from a cenote at Chichen Itza, Yucatan, yielded:[1]

Copper	98.44%
Iron	0.78%
Nickel	trace
	99.22%

[1] Analyses made at University of Pennsylvania by Dr. D. L. Wallace.

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The effigy of a Jaguar from a sacrificial deposit at Chichen Itza gave:[1]

Copper	60.00%
Gold	35.00%
Silver	3.00%
Iron	0.40%
	98.40%

Some metal objects from Tiahuanaco gave interesting results:[1]

Object	Copper	Tin	Iron
Knife	93.80%	6.17%	0
"	96.44%	2.93%	0
Chisel	96.99%	2.51%	0.30%
Hatchet	95.92%	3.27%	0
Pin	91.41%	7.70%	0.41%
Clamp	95.65%	0	1.63%

The following are from the Island of Titicaca:[1]

Object	Copper	Tin	
Hatchet	90.00%	10.02%	True Bronze
Chisel	Copper	None	
"	90.51%	8.92%	True Bronze
Knife	90.00%	9.12%	Bronze
"	97.60%	3.06%	
Drill	94.81%	7.56%	Bronze
Needle	96.00%	4.00%	

These analyses of tools from Tiahuanaco, and the Island of Titicaca are instructive, for they show that while the other nations (with the exception of the Inca) in South America, were undoubtedly in the Stone Age, the builders of Tiahuanaco it seemed had advanced into the Bronze Age and produced tools and implements of that metal.

MA 325

With regard to the Maya civilization it certainly had reached a triumph of architecture and sculpture, but there is little to

[1] Analyses taken from Journal de la Société des Américanistes de Paris.

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show it had reached the Bronze Age. It is doubtful if any specimens of metal work have been found from the First Empire, and such metal objects as have been claimed by the Second Empire may be the copper tools or implements made from the Copper of Oaxaca, Mexico, and possibly were fashioned by the ancient Aztec people.

MA 325

The surprising part of the massive and highly decorated stone structures in Central America, is their elaborate and artistic ornamentation as well as the skill required in quarrying large blocks of stone and joining them together with the cabinet-maker's *accuracy*, and all this with *stone tools*.

Mi 324